This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GA
87
.H3
A3
1889

A 408079

SS

In Memory of
STEPHEN SPAULDING
1907 – 1925
CLASS of 1927
UNIVERSITY OF MICHIGAN

W H W Bicknell 1927

GA
87
.H3
A3
1889

A BRIEF ACCOUNT

OF THE

HAWAIIAN GOVERNMENT SURVEY,

ITS

OBJECTS, METHODS AND RESULTS,

BY

PROF. W. D. ALEXANDER,

SURVEYOR-GENERAL

PUBLISHED BY ORDER OF THE MINISTER OF THE
INTERIOR OF THE HAWAIIAN KINGDOM.

HONOLULU:
BULLETIN STEAM PRINT.
1889.

GA
87
.H3
A3
1889

INTRODUCTORY REMARKS.

Some preliminary explanation seems to be required of the meaning of certain terms used in the following report.

In the first place, each island is divided into several *Moku* or Districts, of which there are six in the island of Hawaii, and the same number in Oahu.

The next subdivision of land below the *Moku* is the *Ahupuaa,* which has been termed the *unit* of land in the Hawaiian system. The *Ahupuaa* is generally a long narrow strip, extending from the sea to the summit of the mountain. On the windward side of the islands, each valley generally constitutes a distinct *Ahupuaa.*

The *Ahupuaa* again are generally subdivided into *Ilis*, each with its own name and carefully defined boundaries.

The term *Kuleana* is commonly applied to the small pieces of land that were awarded in fee simple to the common people, who had formerly been mere tenants at will, liable to be dispossessed at any time, The term *Mahele*, which means "division," is often applied to the Great Division of lands, which was made in 1848 between Kamehameha III. as feudal suzerain and the chiefs, his feudatories, who gave up part of their lands in order to obtain allodial titles to the remainder.

Although the system of land *tenure* was radically changed by the peaceful and beneficent revolution, which took place during the reign of Kamehameha III., yet the ancient subdivisions and boundaries of land remain unchanged to the present day.

To ascertain and define the landed property within this kingdom, has been the chief object of the Government Survey.

The following report, now published for the first time, explains its objects, methods and results.

HONOLULU, April 1, 1874.

HIS EX. H. A. WIDEMANN,
Minister of the Interior.

Sir:

I have the honor to present the following report of the progress of the Government Survey to the beginning of this month. At your suggestion I will make a brief statement of the objects of this Survey, and the advantages to be derived from it.

OBJECTS OF THE SURVEY.

The principal objects of this survey, as I understand them, are 1st, to construct a correct general map of this Kingdom. All the existing maps of the islands are really founded on the original charts made by Cook and Vancouver, and abound in gross errors both in regard to the coast lines, and the relative positions of the smaller islands.

Hardly any district maps exist, or any materials out of which they could be constructed. A nation that claims to be civilized and enlightened, should not rest contented with this state of things.

2nd. It is intended to fix permanently and with the utmost possible accuracy, a great number of points of reference, upon which all the local surveys can be based, and by which they will all be connected together as parts of one great whole.

3rd. To produce a map of each district or *Moku*, which will give an exact representation of the contents and boundaries of its principal subdivisions as *Ahupuaa* and *Ilis*.

In a few of the more thickly inhabited districts, such as Kona, Oahu, all the lands for which Royal Patents or Land Commission Awards have been issued, should be laid down as accurately as possible.

At the same time, the survey ought to present an exact delineation of the shore line, and of the more important topographical features of the country, such as hills, gulches, craters, rivers, forests, roads, plantations, etc., so as to furnish reliable information in regard to the amount of wood land, arable land, pasture land and desert, as well as in regard to the roads, harbors, etc.

It is not, however, proposed to make a regular topographical survey of the country or to run lines of level, except for some special object; although it is intended to measure the heights of all the prominent stations.

Neither will our means enable us to make a general hydrographical survey of the depth of water, and the character of the bottom of the sea around each island.

Our survey differs from similar operations in Europe in not being a military or a purely scientific and topographical survey, but a survey of the *landed property* of the kingdom. It, however, resembles those surveys and the U. S. Coast Survey in being founded on accurate trigonometrical and astronomical measurements.

ADVANTAGES OF THE SURVEY.

It seems hardly necessary to explain the value of such surveys and maps, both to the Government and people of this country.

Formerly, if any one wished to obtain reliable information in regard to a land situated in one of the less known districts, as Kaupo for instance, he was obliged to visit the place in person at great trouble and expense, and would then too often find that the boundaries were indefinite and unsettled.

Now if a map of the district, could be found at the Interior Office showing the location of the land in which he is interested, the adjacent lands, the roads, and the principal natural features of the district, such as forests, ravines, rivers, etc., it would save all this trouble and expense, and would be an important aid in the transaction of any business in real estate.

The more minute maps of special districts, such as Waikiki, Oahu, would serve as an index. to the records in the Interior Office, and would materially assist the officers of the Government both in assessing the value of real estate, and in planning roads, aqueducts and other public works.

Such maps with the accompanying notes of surveys, arranged in the office for convenient reference, would greatly facilitate all transactions relating to landed property, and might be cited as evidence in courts of justice.

Again, such a survey is much needed in order to ascertain what Government lands remain unsold. Few if any surveys of Government lands as such, have ever been made until recently, and it is impossible except by general surveys of this kind. to ascertain what portions are left. This is the case even in the immediate vicinity of Honolulu, and much more so in the remote districts.

The lands held by *private* parties may be divided into two classes: *first,* those which have been surveyed, and the boundaries of which have been settled by Land Commission Awards or by the Boundary Commissioners; and *secondly,* those which have never been surveyed, which latter class includes the greater part of the larger lands called *Ahupuaás.*

It is well known that there was no uniform system of surveying the *Kuleanas.* The work was done in a hasty and fragmentary manner, some of it by incompetent surveyors with inferior instruments, and without reference to other surveys, and the result has been, and will continue to be, much troublesome uncertainty and litigation. It was but seldom that care was taken to mark corners in a permanent manner, so that comparatively few undisputed landmarks remain at the present day. These facts, together with the very irregular local variation of the magnetic needle, make it very difficult to retrace old surveys in this country. To put together these imperfect and conflicting surveys is much more difficult than to put together a dissected map, for the pieces do not match, but overlap in one place, and leave gaps in another.

I do not recommend that the Government should undertake the task of resurveying all the *Kuleanas* throughout the islands. But, as was stated above, there are some districts, such as Honolulu and Lahaina, where it will be well worth while, both for the good of the people, and the information of the Government, to make a thorough examination of all the original surveys. When this is done, the principal corners should be marked in a permanent manner, and the variation of the magnetic needle at the time, recorded, in order to prevent trouble in future.

But a large part of the land in this kingdom has never been surveyed at all. Nearly all the larger divisions of land were awarded by name merely, and notwithstanding the zeal shown by some of the Boundary Commissioners during the past year, many of these lands still remain unsettled, even in the vicinity of the capital.

Some of the lands held by such titles have been subdivided, and have repeatedly changed hands. On account of the negligence or ignorance of their owners, some of these cases will never be cleared up except by a systematic survey of the whole district. There are even yet a few lands held in accordance with ancient custom, which were overlooked in the *Mahele* or Division of 1848, the owners of which never applied to the Land Commission or to the Minister of the Interior for any award. All such cases will be brought to light by such a survey as is proposed.

By the Act of 1862 for settling Boundaries, all owners of lands, whose applications have not been filed with the Commissioners of Boundaries, may be compelled by the Minister of the Interior to have them settled, and to pay double fees.

Private surveyors will receive valuable assistance from the proposed Government Survey in many ways.

1st. It furnishes accurate data for determining the magnetic declination, and the rate of its change from year to year, and also affords a test of the existence of local attraction and a measure of its amount.

2nd. It furnishes bases and azimuths for local surveys more accurate than a private surveyor can generally afford to make.

The plan of the Government Survey when carried out will cover the country with a network of triangles, measured with precision, to serve as a skeleton or framework on which the local surveys are to be based. The corners of these triangles are to be marked in a permanent manner, and will serve as points of reference for future surveys. The true bearings of these points from each other being recorded, will enable any surveyor to find the true bearing of any line in the neighborhood, and the local variation of the magnetic needle. The Government district maps will save future surveyors the trouble of disentangling many a complicated knot.

3d. It will also furnish the correct longitudes and latitudes of hundreds of points, especially along the coast, as well as their bearing and distance from each other. These will always afford a basis upon which future surveys in detail can be made, whenever called for.

In short, any information in the Survey Office should be accessible under proper regulations to members of the profession, and in return copies of all boundary surveys both public and private should be deposited there.

The Government Survey has already given important assistance to many private surveys on Oahu, East Maui and North Hawaii; and the completion of our triangulation is urgently called for by the surveyors at work in those islands.

PLAN OF OPERATIONS.

The first step in such a survey is to make a careful reconnoisance for the selection of the most suitable points for the primary triangulation and the base lines. The character of this country is highly favorable to surveys of this kind, abounding as it does, in commanding heights and projecting headlands. All of the islands except Kauai and Niihau can be connected together by one chain of triangles.

As will be explained further on, the principal base of the whole survey was measured across the isthmus of Maui, the second on the Waikiki plain, and the third on the Waimea plains on Hawaii, with the apparatus of the U. S. Coast Survey.

Great care has been taken for the security and identification of the stations, but the method of marking them varies with the nature of the ground.

The ends of the base lines and other important points are marked by short stone columns sunk deep into the ground, with a hole drilled in the top of each, and filled with a copper bolt, on the head of which cross-lines are cut to mark the centre. When a signal stands on solid rock, a hole an inch or two in diameter is drilled in the rock, and filled with melted lead or a copper bolt marked with cross-lines, and then covered with a small pyramid of stones.

When the nature of the ground admits of it, underground marks are buried from two to four feet below the surface, such as a stone jar or glass bottle with three others buried near the surface, pointing to the lower one.

Other marks are triangular pits dug north, south, east and west of the centre mark and pointing to it, or an iron stake driven down nearly level with the ground, with three rocks placed six feet north, south and east from it, with arrows cut on them pointing to the centre.

The signals for primary stations generally consist of a pole supported by a tripod, i. e. three or four timbers framed together. For the longest lines we need to use "heliotropes" or reflectors, adjusted and pointed by an assistant. The U. S. Coast Survey has given us one as a pattern, from which others can be made at a small expense.

In conducting the primary triangulation, no pains are spared to set the theodolite truly in the centre of each station, and each angle is measured from thirty to sixty times or more with the twelve-inch theodolite, on different parts of the circle, and at different times of day.

The true bearings of the principal lines are determined by a long series of careful observations on the Pole Star. The differences of latitude and longitude can then be calculated to hundredths of seconds, taking into account the spheroidal figure of the earth, as flattened at the poles. The geodetic latitudes and longitudes of all the stations can then be deduced from that of some well ascertained point, such as the Transit of Venus observatory in Honolulu.

To facilitate this part of the work, a set of tables was calculated by the superintendent and printed for use in our survey, adapted to our latitude, and to feet instead of metres. The astronomical expedition to be sent to these islands by the British Government to observe the transit of Venus this year, will probably render us invaluable assistance by determining the latitude and longitude of the three stations which they intend to occupy on Kauai, Oahu and Hawaii, with a degree of accuracy never before attained in these islands.

Each triangle of the primary series forms the basis for a series of secondary triangles, the sides of which are from two to six miles long, and these again are broken up into still smaller triangles, which form the final or tertiary triangulation. The corners of these last are often selected with reference to the boundaries of the principal lands.

The topographical features can then be put in most readily by means of the *plane table.* But all boundaries of lands, and all other lines of which the bearings and distances are to be *recorded,* should be surveyed with the transit or theodolite, and with reference to the true and not to the magnetic meridian. All the record books containing the original observations and measurements, and all the computations are to be filed and indexed in the office for future reference.

HISTORY OF THE SURVEY IN 1871–2.

The Legislature of 1870 appropriated $5,000 to procure the requisite instruments for the Survey, and to make a beginning. Accordingly correspondence was opened with the Superintendent of the U. S. Coast Survey and other scientific gentlemen, and an order for instruments was sent to the celebrated firm of Troughton & Sims of London.

Prof. Peirce, the late Superintendent of the U. S. Coast Survey, and Prof. Hilgard, his assistant in charge of the office, have taken much interest in the undertaking, and have rendered material assistance, both by furnishing valuable information and by the loan of instruments. Among these was a complete set of the apparatus used in measuring subsidiary base lines, which originally cost $500. These instruments were shipped from Washington in March, 1871, but did not reach us till the middle of the following July by way of Sydney and Auckland. In the mean time the superintendent of the survey with his assistants made a reconnoisance of West Maui, Kahoolawe, Lanai and Molokai, selecting the primary stations and setting up signals.

A base line was then chosen, 4 1-7 miles in length, crossing the isthmus nearly at a right angle, the northern end being 7 feet and the southern 164 feet above mean tide. After grading and clearing the line, and making a preliminary measurement with a long wire, the final measurement with the bars was commenced August 18th, and finished September 8th. The mean temperature of the bars during the whole measurement was 94° Fahr.

The last half mile of the line crossed a "travelling dune" of sand and a salt marsh, both of which were bridged by a row of piles, which were aligned with a transit, and driven down till their tops were in a straight line, in order to form a solid support for the bars. The probable error or the measurement is believed not to exceed an inch.

A long series of astronomical observations had next to be made, in order to determine the true bearing of the line, and the latitude and longitude of its extremities.

The true bearing of the line was determined by observing at one end the angle between the Pole Star and a lantern set on the other end, 4 miles distant, and noting the exact time by a chronometer. The difference of longitude between these stations and Honolulu was ascertained by comparing the local time with that of chronometers carried several times back and forth between Honolulu and Kahului.

The next series of operations was the measurement of all the angles of the principal triangles. Of the laborious and delicate nature of this work, no one can form an adequate idea who has not tried to measure angles to a second; and it was greatly hindered by stormy weather.

The instruments ordered from Troughton & Simms did not arrive till November, 1871, a year after they had been ordered, but proved to be first class in every respect. The large transit theodolite, which cost $600, is an admirable instrument, with a horizontal twelve-inch circle reading to one second by two micrometer microscopes, and a vertical circle reading to 5 seconds of arc by two verniers. It is completely fitted up for night observations with lamps, reflectors, etc. A duplicate of it has since been made for the United States Government. The telescope has generally been used with a magnifying power of 36, and is remarkably clear. A bare signal pole has often been distinguished with it at a distance of over twenty miles. A pair of excellent mountain barometers were received at the same time from Troughton & Simms, and the elevation of a great many points has been determined by means of them.

In December, 1871, a station was occupied for a week on the summit of Haleakala, the elevation of which was determined both by triangulation and by the barometers to be 10,030 feet. The first five primary triangles were carefully tested in various ways, and the probable errors of the angles average much less than a second.

In February, 1872, the work of triangulation was suspended for the time, and a special survey commenced of the district including Makawao, Hamakuapoko and Haliimaile. Every house, road, stone wall, gulch, etc., was carefully located by actual survey, all the Royal Patents and other land titles examined and located on the ground, and the more important corners marked in a permanent manner.

Two maps, one a "Progress sketch" of Maui and the neighboring islands, and the other a large map of the Makawao district on a scale of 1,000 feet to the inch, were laid before the Legislature of 1872, to give the members a clearer idea of the objects and character of the Survey.

HISTORY OF THE SURVEY DURING 1872–4.

The Legislature of 1872 having decided to continue the survey, the second base line was selected on the Waikiki plain along the continuation of King street, being 9,760 feet in length. The line was cleared and staked out with aligning staves, and a preliminary measurement made with a wire 40 metres in length, which differed from the final measurement only 4 4-9 inches. The final measurement with the base apparatus was commenced June 8th, and completed June 28th, including the re-measurement of about half the line as a test. The difference between the two measurements was 3-10 of an inch. The mean temperature of the bars during the whole measurement was 93° Fahr.

The next step was to measure sets of angles at the two extremities of the base, and at Puu Ohia (Tantalus) and Kaimuki (Telegraph Hill). Observations were then made at Telegraph Hill to determine the true azimuth or bearing of the triangle sides. Twelve sets of angles of twelve each were measured on three different nights between the Pole Star and a small lantern at the west base, 3.5 miles distant, and the exact time of each observation was noted by a chronometer.

We next proceeded to measure a set of angles with the large theodolite on the highest point of Leahi (Diamond Head).

The instruments were carried up the precipice on the inner "*makai*" side of the crater in the following manner;

An iron stake was driven into the rock at the top of the precipice, to which a pulley was attached with 40 fathoms of whale line. Two men then drew up the instrument boxes, one at a time, while two others climbed up with the boxes, and kept them from touching the rocks anywhere during the ascent. According to our usual plan, four posts had been let deep into the ground on the summit, at equal distances from the centre mark of the station, and their tops sawed off on a level. The feet of the observing table were then firmly screwed to the tops of the posts, so that the theodolite when placed in its sockets was nearly as solid as a rock. These particulars are given to give an idea of some of the difficulties that have to be overcome in carrying on such a survey.

Sets of angles were afterwards measured at Koko Head, at Makapuu Point, and on Mokapu Crater, east of Kaneohe Bay.

These operations were hindered by cloudy and rainy weather, and much difficulty was experienced in transporting the instruments, etc., to and from the above named stations.

The large theodolite had a narrow escape in an unsuccessful attempt to land in the little harbor of Hanauma near Koko Head.

At length, the Oahu triangulation having been completed from the station near the Salt Lake at Moanalua around the south end of Oahu to Mokapu and Heeia in Koolau, the surveying party left for Waimea, Hawaii, in November, to lay the foundation for the survey of that island

After a thorough examination of the region, the third base line was located in the eastern part of the plain, being 13,403 feet in length, and at an average elevation of 2817 feet above the sea. After the usual preliminary work, the final measurement was begun on Dec. 19th, 1872. The mean temperature of the bars during the measurement was 87 ° Fahr. A series of stations was then selected and signals set up over them, including one on the summit of Hualalai, and another on the summit of Mauna Kea erected Dec. 24th. The triangulation was carried to Puako and Kawaihae on the shore and to Puu Loa in Kohala.

The summit of Mauna Kea was found to be 13,805 feet above the sea, and the height of Hualalai, measured for the first time, proved to be 8275 feet. A line of levels was run from the sea at Kawaihae to the base line at Waimea as a check on the trigonometrical measurements, with which it agreed very closely. The Waimea Court House was found to be 2670 feet above mean tide. The approximate latitude was found by 21 observations on the sun and stars.

The preliminary Hawaii triangulation was finished Feb. 19th, and the party returned to Honolulu on the 21st. The Base apparatus was returned to the U. S. Coast Survey by the next steamer.

About the beginning of March 1873, the surveying party received orders to survey the Ewa Lagoon and the adjoining land, a task which we endeavored to execute in a manner that would reflect credit on the Government.

The triangulation was carried from Puowaina (Punchbowl Hill) and Salt Lake station to Puuloa entrance, and about 30 secondary stations around the lagoon were located by triangulation and permanently marked. The map of the region drawn by Mr. C. J. Lyons sufficiently speaks for itself.

This survey has proved to be of great service by furnishing an accurate basis for the surveys of Honouliuli, Pouhala, Halawa, Aiea, Kalauao and Waimalu which have since been made for private parties.

As it was evident that the appropriation would prove insufficient, the surveying party was disbanded, and the primary triangulation discontinued for the present.

Messrs. Brown and Lidgate have since been surveying in Hawaii, and Mr. Lyons in Oahu, all however, working on a uniform plan, and employing the same methods as the Government Survey.

In accordance with my instructions, I then commenced a thorough examination of the records with reference to Government lands, making an index of all the Government land sales on Oahu, classified by locality, and surveying the Government lands in Kewalo and Pawaa, south of Honolulu. A list was also made of all the *Ahupuaas* and *Ilis* in the districts of Ewa and Kona, with an account of their original titles, preparatory to the district maps. All the surveys of lands in Honolulu made for the Land Commission have also been copied into a separate book. A map was also commenced of the section of Kona lying south of Alapai Street, showing all the Royal Patents and other subdivisions.

In the latter part of August I began the survey of Honouliuli and the Crown land of Pouhala and finished the field work Oct. 20th. I afterwards drew a map embracing a section of country about eleven miles square, and including most of the Waianae range of mountains. This survey was a continuation of the Ewa lagoon survey, and forms another step towards the map of the whole island.

During the first three months of 1874, I have been chiefly engaged in surveying the Government and private lands in Makiki and Waikiki; among which were many lands the boundaries of which had never been settled.

SCIENTIFIC MATTERS.

While scientific objects have not been allowed to interfere with the progress of the survey, we have not wholly neglected our opportunities in this line.

During the latter part of 1872 a self-registering tide gauge, constructed by Mr. F. L. Clarke, was in operation at the Honolulu Light-house for several months. It finally broke down, owing to a failure of the clock work, but its records are sufficient to indicate the general laws of the tides at this place. A second tide gauge at Hilo was swept away by an extraordinary rise of the sea, but has been replaced, and is again in operation. A new tide gauge of the most improved pattern, has been promised us by the U. S. Coast Survey.

The variation of the magnetic needle has been recorded at almost every station occupied during the survey. The mean declination of the magnetic needle for this island appears to be about 9° 20' East at this time, but the local variations are very great, especially on the ridges and in the deep valleys in the interior of the island. It may be added that during the survey collections have been made and facts observed, which it is believed, will add to our knowledge of the geology and botany of these islands.

PROPOSED PLAN OF OPERATIONS.

For the next biennial period I would respectfully recommend, 1st. That the primary triangulation be carried on as rapidly as possible, first around the northern end of Oahu, so as to complete the coast line, and to connect together the principal surveys on this island, and then around West Maui and the adjoining islands.

2d, That a thorough survey in detail of the district of Kona, Oahu, which has been commenced, and for which considerable material has been collected, be carried on to completion.

3d, That the examination of all the records relating to Government lands be continued, and that the boundaries of these lands be examined, and determined by the Boundary Commissioners wherever they are still unsettled.

The amount appropriated by the last Legislature will all be needed if the work is to be prosecuted with vigor. * * * * * * The preliminary work, the most expensive and tedious part of the work, has been done, and it is believed that its accuracy can be relied on. It will bear comparison with similar surveys made in other countries.

The remaining work can be carried on at less expense and with more apparent results.

I have the honor to remain,

Your obedient servant,

W. D. ALEXANDER,

Surveyor-General.

PROGRESS OF THE SURVEY SINCE 1874.

The foregoing Report explains the objects and methods of the Survey, and relates the history of its commencement.

The corps of surveyors has always been very small, and has been obliged to perform an immense amount of work in examining and locating land titles, and in preparing maps, etc., besides the general survey of the country. The survey of Government lands, and the settlement of boundaries have been the chief objects aimed at rather than geodetic or topographical work.

TRIANGULATION.

OAHU.

On Oahu the triangulation was carried in 1875 and 1876 from West Base around by the South Point and Mokapu on the west, and again by way of Ewa and Waialua around the north end of the island, closing at Laie on the north-west, within 12 feet in a circuit of over 100 miles through thirty triangles. Two stations on the lofty peaks of Konahuanui and Puu Ohulehule were never occupied with instruments. The azimuths coincided within 0''.5.

Another series of triangles was carried through the difficult district of Waianae on the west side of the island. On this network of triangles have been based numerous surveys and maps of districts and of lands as well as charts of harbors.

The triangulation of Oahu was connected with that io the windward islands by occupying the three stations, Mokapu, Diamond Head or Leahi, and Mauna Loa, Molokai, successively with the 12-inch theodolite and with heliotropes.

MAUI.

On Maui the triangulation was resumed in 1876, and carried first around East Maui and across the crater of Haleakala ; and then over the adjoining islands, Kahoolawe, Lanai and Molokai and around West Maui to the North Base. This last circuit closed within eight feet. The triangles connecting the islands of Molokai, Lanai and West Maui were measured with the aid of heliotropes. Messages were exchanged across the Pailolo channel, the Morse alphabet being used.

In order to connect this system of triangles with that of Hawaii, a station was occupied on the summit of Haleakala, at an elevation of 10,000 feet, while an assistant was stationed at Puu Loa, Kohala, both observers signalling to each other with heliotropes, and observing on the Kahoolawe station.

A base of verification was measured on Molokai in 1885. The result was that its measured length differed from that deduced by computation from the Maui base by 0.10 of a foot in 6719 feet.

Since then complete surveys have been made of the islands of Maui and Lanai, while that of Molokai is approaching completion.

HAWAII.

The survey of Hawaii was resumed in 1876 by Mr. Lyons. From the original quadrilateral measured at Waimea in 1872, he continued the series of triangles across the country to the south-east as far as Hilo. In order to do this, it was found necessary to occupy several stations on Mauna Kea at such an elevation as to overlook the wide belt of forest intervening between the interior of the island and the strip of open country, which borders the eastern coast. The whole series from Waimea to Hilo contained 67 triangles. This work was tested in 1881 by the measurement of a base of verification at Hilo, and by a long series of observations on the Pole star for azimuth, the result of which was highly satisfactory. The measured length of the line differed from that deduced by calculation from the Waimea base, 0.2 of a foot in about two miles. The azimuth obtained by the observations differed 1" from that brought from Maui.

In 1881 Mr. Lydgate continued the triangulation through Kohala to the north point of the island.

Since then Mr. Emerson has extended the net-work of triangles down the west coast through the Kona districts to the summit of Mauna Loa and nearly to the south point or "Ka Lae."

The station on the summit of Mauna Hualalai, which commands an extensive view of the coast, served as a pivot or radiating point for the triangulation of the district. The districts of Puna and Kau on the S. E. side of Hawaii are only partially surveyed as yet.

KAUAI.

A reconnoisance and preliminary triangulation of Kauai was executed in 1877 and 1878, which served as the frame-work for a map of that island, which was chiefly compiled from previous surveys.

SURVEYS IN DETAIL.

The frame-work thus laid down has been filled out in accordance with the plans proposed in the outset. The principal topographical features of the country have been indicated, especially where public improvements, such as roads, water-works, irrigation projects, etc., are concerned. The Geology of the islands, has not been neglected, and in particular, changes in the volcano of Kilauea have been carefully noted.

The first attention, however, has been paid to the survey of Government lands, within which all the *kuleanas* or homesteads and Government land sales are accurately located as the survey proceeds.

In the more thickly settled districts and in towns every land title has been carefully investigated and mapped. On account of the minute subdivision of the land, and the gross inaccuracy of the old surveys, this work requires no little research and the most scrupulous accuracy.

At present the time of the surveying corps is largely taken up with the work of selecting, surveying and dividing suitable Government lands into allotments for settlers, according to the provisions of the "Homestead Act."

MAPS, ETC.

The maps of separate *islands* have generally been drawn on a scale of 1:60 000, (2) those of *districts* on a scale of 1: 12000, or 1: 6000, (3) those of *towns* on a scale of 1: 2400 or 1:1200, while (4) plans of city squares or *blocks* are drawn on a scale of 1: 240, representing not only the buildings, etc., but also the titles by which the land is held.

Our published maps have been photolithographed in the United States, chiefly by J. Bien & Co. of New York.

We have published a map of the whole group made in 1876 on a scale of 1: 480 000, maps of Oahu and Maui on a scale of 1: 60 000, one of Hawaii on a scale of 1: 240 000, and one of Honolulu and its environs on a scale of 1: 12000, besides a chart of Hilo Bay.

Relief maps have also been constructed of Oahu and Maui by Prof. C. H. Hitchcock from data furnished by the survey.

The task of compiling, arranging and indexing a vast mass of information relating to real estate titles has devolved upon this Bureau. A history of Hawaiian land titles and a classified index of Government land sales have been prepared and published by this Bureau.

The Legislature of 1888 has also imposed upon our staff the duty of supplying all the Tax Assessors with "maps in detail, of taxation divisions, showing all original titles and areas, and as far as possible, all present titles."

HYDROGRAPHY.

During the years 1882–1886, nearly all the harbors and roadsteads in the group were surveyed for the Government by Capt. G. Jackson, a retired navigating lieutenant of the

British Navy. Several of these surveys have been published by the British Admiralty. In 1883 he executed a series of deep sea soundings between the principal islands, to prepare the way for the laying of a projected inter-island telegraphic cable.

A self-recording tide gauge, loaned by the U. S. Coast and Geodetic Survey, has been kept in operation in Honolulu harbor since 1880. The observations are reduced and analyzed by the staff of that survey in Washington, U. S.

ASTRONOMICAL WORK.

As before stated, the latitudes and longitudes adopted for Oahu were based upon the position of the Transit of Venus observatory at Honolulu as determined by Col. Tupman in 1874.

As the survey of the windward islands was not connected with that of Oahu for several years, an independent determination had to be made of the position of the North Base on Maui, the correctness of which has been fully confirmed by Mr. Preston's recent observations.

After the intervening triangulation had been completed, there appeared a large discrepancy, which could only be explained by extraordinary deflections of gravity.

In order to thoroughly test this matter, a series of latitude observations of precision were made in 1887, at fourteen stations on the principal islands, which were in general north and south of the highest mountains. This work was executed by Mr. E. D. Preston of the U. S. Coast and Geodetic Survey, who had received leave of absence from his government, which also loaned the necessary instruments.